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US ARMY
MATERIEL COMMAND

MANUFACTURING METHODS & TECHNOLOGY

PROJECT SUMMARY REPORTS

JULY 1986

PREPARED BY

USA INDUSTRIAL BASE ENGINEERING ACTIVITY
MANUFACTURING TECHNOLOGY DIVISION
ROCK ISLAND, ILLINOIS 61299-7260

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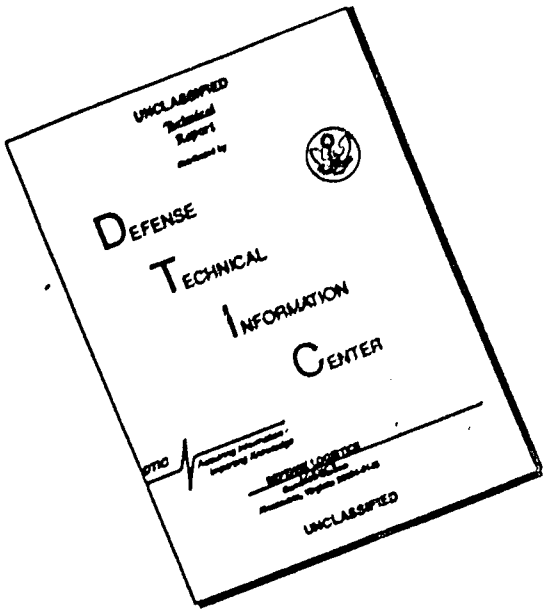

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US ARMY INDUSTRIAL BASE ENGINEERING ACTIVITY
ROCK ISLAND, ILLINOIS 61299-7260

REPLY TO
ATTENTION OF

AMXIB-P

23 July 1986

SUBJECT: Manufacturing Methods and Technology Program Project Summary Report (RCS DRCMT-302)

SEE DISTRIBUTION: (Appendix II to Enclosure 1)

1. In compliance with AR 700-90, dated 13 March 1986, the Industrial Base Engineering Activity (IBEA) has prepared the enclosed Project Summary Report.

2. This Summary Report is a compilation of MMT Summary Reports prepared by IBEA based on information submitted by AMC Major Subordinate Commands and Project Managers. To simplify and facilitate technology transfer, Summary Reports are now being prepared for a completed effort rather than for each funded year. In addition, the reports have been pared down to one page. Persons who are interested in the details of a project should contact the project officer indicated at the conclusion of each individual report.

3. Additional copies of this report may be obtained by written request to the Defense Technical Information Center, ATTN: TSR-1, Cameron Station, Alexandria, VA 22304-6145.

FOR THE DIRECTOR:

James W. Carstens

JAMES W. CARSTENS
Chief, Production Engineering Division

Encl

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20. ABSTRACT (Continue on reverse side if necessary and identify by block number)
This report contains summaries of 26 efforts that were completed under the Army's Manufacturing Methods and Technology (MMT) Program. The MMT program was established to upgrade manufacturing facilities used for the production of Army materiel. The summaries highlight the accomplishments and benefits of the projects and the implementation actions underway or planned. Points of contact are also provided for those who are interested in obtaining additional information.

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INTRODUCTION

Background

The Manufacturing Methods and Technology (MMT) Program was established to upgrade manufacturing facilities used for the production of Army materiel, and, as such, provides direct support to the Industrial Preparedness Program. The Manufacturing Methods and Technology Program consists of projects which provide engineering effort for the establishment of manufacturing processes, techniques, and equipment by the Government or private industry to provide for timely, reliable, economical, and high-quality quantity production means. The projects are intended to bridge the gap between demonstrated feasibility and full-scale production. The projects are normally broad based in application, are production oriented, and are expected to result in a practical process for production. The projects do not normally include the application of existing processes, techniques, or equipment to the manufacture of specific systems, components, or end items, nor do they apply to a specific weapon system development or a product improvement program.

MMT Program Participation

MMT Programs are prepared annually by AMC Major Subordinate Commands. These programs strive for the timely establishment or improvement of the manufacturing processes, techniques, or equipment required to support current and projected programs.

Project proposals (Exhibit RD-6s or format) are submitted to the appropriate MMT Program office. A list of offices is provided in Appendix I. Additional information concerning participation in the MMT Program can be obtained by contacting an office listed or by contacting Mr. James Carstens, AUTOVON 793-5113, or Commercial (309) 782-5113, Industrial Base Engineering Activity, Rock Island, IL 61299-7260.

In anticipation of the lengthy DOD funding cycles, projects must be submitted in sufficient time for their review and appraisal prior to the release of funds at the beginning of each fiscal year. Participants in the Program must describe manufacturing problems and proposed solutions in Exhibit RD-6 formats (see AR 700-90, 13 March 1986, for instructions). Project manager offices should submit their proposals to the Command that will have mission responsibility for the end item that is being developed.

Contents

This report contains summaries of 26 completed efforts that were funded by the MMT Program. The summaries are prepared from Project Status Reports (RCS DRCMT-301) and Final Technical Reports submitted by organizations executing the MMT projects. The summaries highlight the accomplishments and

benefits of the projects and the implementation actions under way or planned. Points of contact are also provided for those interested in obtaining additional information.

The MMT Program addresses the entire breadth of the Army production base and, therefore, involves many technical areas. For ease of referral, the project summaries are grouped into six technical areas. The technical areas are: CAD/CAM, Electronics, Inspection and Test, Metals, Munitions, and Non-Metals. Abstracts were prepared to highlight projects which achieved noteworthy accomplishments.

This report was also organized and bound to facilitate its disassembly. A disassembled report may be used to selectively circulate certain summaries and for filing of selected summaries for future reference.

The Summary Reports are prepared and published for the Deputy Chief of Staff for Production, AMC, by the Production Engineering Division of the US Army Industrial Base Engineering Activity (IBEA) in compliance with AR 700-90. The report was compiled and edited by Mr. Wayne R. Hierseman and ably assisted by Ms. Deborah Johns with the typing arrangements.

COMPUTER AIDED DESIGN/
COMPUTER AIDED MANUFACTURING
(CAD/CAM)

MANUFACTURING METHODS AND TECHNOLOGY
PROJECT SUMMARY REPORT (RCS AMCPD-302)

4 5024 Gear Die Design & Manufacturing Utilizing Computer Technology (CAD/CAM)

PERFORMING ORGANIZATIONS:

MSC/INSTALLATION: US Army Tank-Automotive Command
PROJECT OFFICER: Don T. Ostberg
PHONE NO: COMMERCIAL - (313) 574-5814
AUTOVON - 786-5814
CONTRACTOR: Battelle Columbus Division
LOCATION: Columbus, Ohio 43201-2693

TECHNOLOGY DEVELOPED: The project objective was to use Computer Aided Design and Manufacturing (CAD/CAM) techniques for determining optimum preform and close tolerance precision forging die design from which spiral bevel gears could be produced. Close tolerance precision forging would require minimal or no finish machining. By precision forging the tooth form and other critical dimensions manufacturing cost would be significantly reduced. The existing data on close tolerance precision forged gears indicate that these gears are superior in terms of load carrying capabilities and increased fatigue life. Currently a few companies produce spiral bevel gears to near-net tolerance by precision forging. However, the development of the gear design is determined through trial and error. The application of CAD/CAM to the entire family of bevel gears offers an attractive alternative.

In this effort, Battelle developed a computer program called "SPBEVL" for producing precision near-net tolerance spiral bevel gear forgings. The "SPBEVL" computer program determines the optimum preform (or blocker) design assuring defect-free metal flow, adequate die filling and minimum flash. "SPBEVL" also has the capability to design the forging dies. "SPBEVL" will predict the machine settings required to machine the Electro Discharge Machine (EDM) electrodes used to cut the forging dies. "SPBEVL" output gives machine settings, bulk shrinkage, the correction due to deflection resulting from: forging load and temperature differential between the die and workpiece.

This CAD/CAM design process was demonstrated on a 16 1/2 inch spiral bevel ring gear. The forging of the near-net tolerance ring gear was produced and dimensionally inspected. The measurements were within the desired tolerance, except for a .005 inch maximum variation in tooth form. The out of tolerance condition was almost totally due to spiral bevel angle error. This error, it is expected, can easily be corrected in future die design and was easily removed in subsequent machining operations. The gear forgings were machined, heat treated and lapped (with the pinion) into matched sets which are the common finish practices with spiral bevel gear sets.

The results of the project indicate that the use of CAD/CAM near-net tolerance forging of spiral bevel gears is a practical technique that would reduce manufacturing cost.

Summary report prepared by Rolf Anderson, AMXIB-PG, Production Engineering Division, U.S. Army Industrial Engineering Activity, Rock Island, IL 61299-7260, Commercial (309) 782-5235, AUTOVON 793-5235

ELECTRONICS

MANUFACTURING METHODS AND TECHNOLOGY
PROJECT SUMMARY REPORT (RCS AMCPD-302)

T 5067 Plastic Battery Box

PERFORMING ORGANIZATIONS

MSC/INSTALLATION: TACOM/Warren, Michigan
PROJECT OFFICER: D. McClendon
PHONE NO: COMMERCIAL - (313) 574-6491/2
AUTOVON - 786-6491/2
CONTRACTOR: Rotocast Plastic Products, Inc.
LOCATION: Miami, Florida

TECHNOLOGY DEVELOPED: Battery boxes, in which the batteries for M39 and M809 Tactical Vehicles are placed, are made from deep drawn low carbon steel. Even though they are coated, they corrode rapidly when battery acid is spilled. Most batteries are designed to breathe and the fumes which escape through the vents under high humidity conditions tend to condense as liquid acid on the battery box floor. To avoid damage to other parts, the corroded boxes must be replaced frequently.

The battery boxes are made by a high-speed stamping process which is inexpensive. Hence, the goal was to replace the metal boxes with a cheap, non-corrosive plastic.

The first material, nylon 6/6, which was selected by the contractor for the construction of the battery retainer, was not suitable. The second fabrication of the retainers, using polypropylene with glass filling, showed marked rigidity improvement and resistance to corrosive gases. The glass portions studied were 15% and 30% and both gave satisfactory results.

Rotationally molded, cross-linked, high-density, polyethylene material, was selected for the construction of the battery box and step-cover. This was found to be sufficiently resistant to corrosive acids to serve as the replacement material for the metal battery box. This material also has the necessary physical properties suitable for this application.

During the field testing of the new battery box, the plastic components exhibited no deterioration or distortion. Drivers and mechanics preferred the plastic battery box, step-cover, and retainer because they weigh less, they do not corrode, and they do not require painting. Another incidental advantage for the new boxes was also found. Since plastic does not conduct electricity, there is less chance of shorting the battery terminals while installing the batteries or reinstalling the step-cover.

Summary report was prepared by Wayne R. Hierseman, AMXIB-PG, Production Engineering Division, U.S. Army Industrial Engineering Activity, Rock Island, IL 61299-7260, Commercial (309) 782-5235, AUTOVON 793-5235

MANUFACTURING METHODS AND TECHNOLOGY
PROJECT SUMMARY REPORT (RCS AMCPD-302)

5 3062 Pellet Thermal Power Supply Technology

PERFORMING ORGANIZATIONS

MSC/INSTALLATION: AMCCOM/Harry Diamond Laboratories
PROJECT OFFICER: Dr. J. T. Nelson
PHONE NO: COMMERCIAL - (202) 394-3114
AUTOVON - 290-3114
CONTRACTOR: None
LOCATION: N/A

TECHNOLOGY DEVELOPED: The purpose of this effort was to establish a manufacturing technology posture for pellet-type thermal batteries. In the past, manufacture of such batteries has been on a low volume basis. A considerable amount of tailoring of small batches of materials and components was necessary to obtain batteries that met specifications. This approach precluded the attainment of low cost devices.

Full scale manufacturing batches of materials were prepared and a substantial number of batteries were made. Physical and chemical analysis of the material batches coupled with the battery testing was then carried out with the intention of assessing manufacturing reproducibility.

Commercial and in-house-prepared depolarizer-electrolyte-binder (DEB) powders and constituents have been characterized in terms of chemical composition, homogeniety, surface area, impurity content and flow characteristics in the molten state. These characteristics have been correlated with the electrochemical performance of batteries built with these powders.

While no quick and simple test for powder acceptability has been found, it has been determined that for thermal batteries with severe performance requirements, the binder content of the DEB powder used is quite critical. Also, for powders in the acceptable binder content range, powder uniformity is quite critical. Further, it has been shown that unacceptable powder with the proper binder content can be made acceptable by reheating and/or reblending to improve uniformity.

Summary report was prepared by Wayne R. Hierseman, AMXIB-PG, Production Engineering Division, U.S. Army Industrial Engineering Activity, Rock Island, IL 61299-7260, Commercial (309) 782-5235, AUTOVON 793-5235

INSPECTION AND TEST

MANUFACTURING METHODS AND TECHNOLOGY
PROJECT SUMMARY REPORT (RCS AMCPD-302)

5 4557 MMT Application of Radar to Ballistic Acceptance Testing of Ammunition (ARBAT)

PERFORMING ORGANIZATIONS

MSC/INSTALLATION: AMCCOM (Dover)
PROJECT OFFICER: Joseph Secko
PHONE NO: COMMERCIAL - (201) 724-4758
AUTOVON - 880-4758
CONTRACTOR: ITT Gilfillan
LOCATION: Van Nuys, CA

TECHNOLOGY DEVELOPED: During the 1970's, a need developed for a real-time instrumented radar to obtain ballistic data on projectile flight from launch to impact. ITT Gilfillan, Van Nuys, California, developed a prototype ballistic radar system that can be used to test ammunition items from 40mm to 16-in projectiles, including artillery projectiles, mortar rounds, rockets, rocket-assisted projectiles (RAP) and improved conventional munitions (ICM), including cargo carrying projectiles. Examples are M483, M549, M650, XM785 and the M577 fuze.

The ARBAT System, the ITT Gilfillan developed artillery tracking instrumentation radar prototype, was officially transferred from AMCCOM to TECOM at Yuma Proving Ground in January 1985. The ARBAT system provides a unique real-time computer capability to identify all critical flight ballistic parameters from launch to impact, and projectile malfunctions such as early ignition, rocket separation, early or late fuze function and tumbling.

For the first time, the Army is able to obtain real-time ballistic test data with the added benefit that the ARBAT system does this 5 times cheaper than the existing radar system. This prototype is expected to save over $1 million per year at Yuma Proving Grounds.

TECOM is planning to purchase 4 production ballistic radar systems to be installed at Yuma Proving Grounds, Dugway Proving Grounds, and Jefferson Proving Grounds at a cost of $25.5 million. This new radar system is designated as the AN/MPQ-63 Instrumentation Ballistic Radar. Foreign countries have shown interest in this new system.

For more information, contact Joseph Secko, AMCCOM (Dover), AMSMC-QAH, AV 880-4758 or Commercial (201) 724-4758.

Summary report was prepared by Ken Russell, AMXIB-PA, Production Engineering Division, US Army Industrial Base Engineering Activity, Rock Island, IL 61299-7260, Commercial (309) 782-6226, AUTOVON 793-6226.

METALS

MANUFACTURING METHODS AND TECHNOLOGY
PROJECT SUMMARY REPORT (RCS AMCPD-302)

1 7036 Isothermal Roll Forging of T-55 Compressor Blades

PERFORMING ORGANIZATIONS:

MSC/INSTALLATION: U.S. Army Material and Mechanical Research Center
PROJECT OFFICER: Roger Gagne
PHONE NO: COMMERCIAL - (617) 923-5579
AUTOVON - 955-5579
CONTRACTOR: Solar Turbine Incorporated
LOCATION: San Diego, CA 92138-5376

TECHNOLOGY DEVELOPED: This effort established the isothermal roll forging process for producing precision compressor blades for engine application at reduced cost. The typical turbine engine requires a large quantity of compressor blades, a major contributor to the high cost of turbine engines. The current method of fabrication requires many operations that are difficult and require a considerable amount of hand-finishing.

The isothermal roll forging process, called Solaforge, was developed by Solar Turbine Inc. This process uses refractory metal roll type dies heated by the flow of controlled electric current from die to die through the workpiece. The control is provided by temperature feed back from twopyrometers sighted on the workpiece. Force feed of the workpiece is used to prevent roll die slippage at large thickness reduction and promotes lateralspreading of metal.

Two sets of blades for the Avco Lycoming T-55 Engine were manufactured by the isothermal roll forging process with post-forge processing performed by the current manufacturer of T-55 blades, Kelsey Hayes Co. The blades were manufactured to meet the specification requirements. Evaluation included metallographic structure, mechanical properties and analysis of dimensional control. This showed that all the current engine requirements for the blades could be met.

Economic evaluation showed that the capital investment required by a shop already set-up for blade manufacturing gave a negative internal rate of return (IRR) of 16.7% when small quantities were required (e.g. 15,000 to 30,000 per year). An improved process using a single pass increased the IRR to 18.8% for this quantity, but was at the limits of squeeze and current capacity of the present machine. The quantity requirement for the T-55 blade is well under the full production capacity of the machine. One machine at 100% utilization (45,000 blades per year) would offer a IRR of 29.2%. The process was proposed initially for titanium blades. Early in Phase I of this effort, a shift to steel blades for the engine reduced the saving available by this process.

This effort provided the technology to produce blades by isothermal forging with a high degree of automation and reduced the number of operations and amount of hand-finishing required.

Summary report was prepared by Rolf Anderson, AMXIB-PG, Production Engineering Division, U.S. Army Industrial Engineering Activity, Rock Island, IL 61299-7620, (309) 782-5235, AUTOVON 793-5235

MANUFACTURING METHODS AND TECHNOLOGY
PROJECT SUMMARY REPORT (RCS AMCPD-302)

4 6098 Production of Special Armor Steel

PERFORMING ORGANIZATIONS:

MSC/INSTALLATION: TACOM
PROJECT OFFICER: D. Phelps
PHONE NO: COMMERCIAL: (313) 574-5444
AUTOVON: 786-5444
CONTRACTOR: U.S. Steel
LOCATION: Pittsburgh, PA

TECHNOLOGY DEVELOPED: The need for improved armor steels is a continuing requirement in the design of combat vehicles. Any material improvement that can enhance protection capability without resulting in added armor weight improves equipment survivability.

The objective of this project was to demonstrate the producibility of textured armor steel in a production environment and to perform an evaluation of this material for mechanical and ballistic properties. A need exists for an industrial facility capable of producing, on a commercial basis, the special steel with superior ballistic properties required to achieve a maximum level of protection for tank armor and other combat vehicles.

The manufacturing problem areas encountered were close dimensional, temperature control and techniques for quenching. Commercially available production facilities were utilized and modified as necessary. The goal was to transfer the known processing requirements into the appropriate production steps in terms of:

- rolling mill dimensional size
- reduction schedule data
- rolling temperature control, and
- quenching techniques for armor plate.

The completed project established process parameters to produce special steel armor plate for combat vehicles. The contractor successfully rolled steel plate in thicknesses ranging from 3/16 to 2 inches, achieving a satisfactory texture and demonstrating that the commercial equipment can produce the desired material properties. The improved material is ready for consideration as an armor design component.

The technical report is classified For Official Use Only (FOUO).

Summary report was prepared by Wally Graham, AMXIB-PG, Production Engineering Division, U.S. Army Industrial Engineering Activity, Rock Island, IL 61299-7260, Commercial (309) 782-5235, AUTOVON 793-5235

MANUFACTURING METHODS AND TECHNOLOGY
PROJECT SUMMARY REPORT (RCS AMCPD-302)

5 4444 Body for M42/M46 Grenade

PERFORMING ORGANIZATIONS:

MSC/INSTALLATION: AMCCOM
PROJECT OFFICER: V. Grasso
PHONE NO: COMMERCIAL - (201) 724-4636
AUTOVON - 880-4636
CONTRACTOR: MB Associates
LOCATION: Orlando, FL

TECHNOLOGY DEVELOPED: The objective of this effort was to determine a more economical method to produce metal parts for the M42 and M46 Grenades.

Contracts were originally placed with Avco, Dayron, Gulf-Western, and MB Associates (MBA) to develop four alternative concepts of manufacturing processes and product prototype parts for evalution. The concept evaluation resulted in the selection of Dayron and MBA processes for further evaluation.

The Dayron and MBA process both consisted of a two piece design. Dayron encountered problems in meeting dimensional requirements, caused by the tube rolling mill from which the two piece body was to have been made. After several unsuccessfull attempts to solve the problem, Dayron's contract was terminated. MBA redesigned their manufacturing process to produce a one piece body to overcome dissatisfaction of the joint. The one piece body manufacturing process starts with bar stock cut into a slug, extruded through dies, restriking to form the shape, and final machining. A contract was awarded to MBA to manufacture grenade bodies of the one piece design, which were loaded and assembled into projectiles for ballistic tests to be conducted at Yuma Proving Grounds. The rounds were conditioned and fired in accordance with the test plan requirements (TPR).

Examination of the recovered grenades showed no unusual conditions when compared to current grenades. The submunition impact pattern on the field was consistent with the standard projectiles. Evaluation of the data showed that the extrusion process is capable of producing a M46 equal to the current M46; however, the lethality of the extruded M42 was 17% less than the current M42. A Product Improvement Proposal (PIP) was funded to study and improve the extruded M42 pattern.

The results of an economic analysis indicates savings of approximately 9 cents per grenade body could be achieved. In 1982, 74,000,000 grenades were produced. If the MBA process were used, a savings of $6,660,000 would have been realized.

Summary report was prepared by Rolf Anderson, AMXIB-PG, Production Engineering Division, U.S. Army Industrial Base Engineering Activity, Rock Island, IL 61299-7260, Commercial (309) 782-5235, AUTOVON 793-5235.

MANUFACTURING METHODS AND TECHNOLOGY
PROJECT SUMMARY REPORT (RCS AMCPD-302)

5 4563-01 Process Improvement for Tank Depleted Uranium (DU) Penetrators

PERFORMING ORGANIZATION:

MSC/INSTALLATION: U.S. Army Armament Research and Development Center
PROJECT OFFICER: Mr. William R. Sharpe
PHONE NO: COMMERCIAL - (201) 724-6506
AUTOVON - 880-6560
CONTRACTOR: Nuclear Metal Inc.
LOCATION: Concord, MA 01742

TECHNOLOGY DEVELOPED: The production process currently in use has proven incapable of meeting cycle time and quantities of deliverable depleted uranium (DU) 3/4 TI penetrators. A contributing cause is the warping of the cores during manufacturing. Production can be increased by maintaining straight material with a maximum bow of .050 in/ft Total Indicator Reading (TIR) from extrusion through heat treat. Improved straightness will allow for a more efficient method of cutting blanks to premachine length and reduce the rejection rates due to warped cores.

This project established methodology which will improve straightness of DU in the "as-extruded" condition.

Four straightening methods were initially investigated: roll, squeeze, stretch, and rotary. Rotary straightening was determined to be the most viable method to pursue for parameter optimization. A problem with the copper cladding peeling off the uranium core resulted in interference with the rotation of the rod. Removal of the copper cladding by pickling resolved this problem. There was a concern that straightening at ambient temperature would result in high residual stress. Tests revealed to the contrary, that straightening at ambient temperature produced the straightest rods and residual stress was insignificant.

A final trial was conducted on five full length extruded rods that were pickled and rotary straightened at ambient temperature. All five rods were processed without incident and resulted in a overall maximum bow of only .007 in/ft TIR. This surpassed the straightness requirement of .050 in/ft maximum TIR established at the onset of the project.

The rotary straightening method developed will permit production capabilities to meet time cycle and quantities of deliverable DU 3/4 TI penetrator blanks. Based upon a rate of 14,000/month, it is estimated that 2,700 hr/yr will be saved which represents a savings of $124,000 annually.

Summary report was prepared by Rolf Anderson, AMXIB-PG, Production Engineering Division, U.S. Army Industrial Engineering Activity, Rock Island, IL 61299-7620, Commercial (309) 782-5235, AUTOVON 793-5235

MANUFACTURING METHODS AND TECHNOLOGY
PROJECT SUMMARY REPORT (RCS AMCPD-302)

5 4563-05 Process Improvement for Tank Penetrators,
Facet 5, Reduction of Chip Oxidation

PERFORMING ORGANIZATIONS:

MSC/INSTALLATION: U.S. Army Armament Research and Development Center (ARDEC)
PROJECT OFFICER: W. R. Sharpe
PHONE NO: COMMERCIAL (201) 724-6506
AUTOVON 880-6506
CONTRACTOR: South Creek Industries Inc.
LOCATION: Rexford, NY 12148

TECHNOLOGY DEVELOPED: Oxidized depleted uranium (DU) machine chips (waste material) and the costs associated with special handling, transportation, and disposal of these waste chips are inherent problems in the production of DU tank penetrator. Oxidation during the machining cycle causes waste material that is difficult to reuse. Controlling the oxidation process during machining can reduce or eliminate the amount of waste material produced by making the
the machining chips more amenable to recycling.

The objective of this project was to determine the feasibility of using an inert atmosphere to reduce oxidation during machine of DU.

Chemical analysis of DU material for oxygen and carbon at various machining stages was carried out since this was believed to be an important factor in the oxidation process. The chemical analysis of chips machined in open-air using water soluble oil coolant resulted in a mean value of 215 PPM oxygen and 93 PPM carbon. Chemical analysis of chips machined in a controlled inert atmosphere using dry argon gas coolant and inert atmosphere resulted in a mean average of 76 PPM oxygen and 53 PPM carbon. The effectiveness of the inert atmosphere was therefore demonstrated.

The machining chips produced in a controlled argon atmosphere were also checked to verify their suitability for recycling. Chips were placed in an electric resistance furnace and successfully melted into a solid mass containing minimal oxide inclusions.

The machining parameters utilized in this project were significantly different from those used in current penetrator production. Therefore, ARDC has requested additional MMT funding for future work in this area.

Summary report was prepared by Rolf Anderson, AMXIB-PI, Production Engineering Division, US Army Industrial Engineering Activity, Rock Island, IL, 61299-7260, Commercial, (309) 782-5235, AUTOVON, 793-5235

MANUFACTURING METHODS AND TECHNOLOGY
PROJECT SUMMARY REPORT (RCS AMCPD-302)

5 4580 UV-Cure Paint for Large Caliber Projectiles

PERFORMING ORGANIZATIONS:

MSC/INSTALLATION: AMCCOM/ARDC, Dover, N.J.
PROJECT OFFICER: Gary C. Nelson
PHONE NO: COMMERCIAL - (201) 328-6514
AUTOVON - 880-6514
CONTRACTOR: NI Industries
LOCATION: Los Angeles, CA

TECHNOLOGY DEVELOPED: Currently, large caliber projectiles are spray-painted with conventional solvent-cut alkyd paints which are subsequently dried and cured as the painted shells pass through an oven on a conveyor chain. The volatile organic compounds (VOC's) that are evolved during drying are taken away through exhaust ducts and discharged into the atmosphere. Since ultraviolet (UV) cure paints contain no VOC's, their use would avoid the high cost of installing and operating air pollution abatement equipment. The use of UV cure paint would also eliminate the high cost of operating paint curing ovens.

The overall objective of this project was to establish the feasibility of using UV cure paint for large caliber projectiles. A contract was awarded to NI Industries to conduct the project effort. John Brown Associates (JBA) was contracted by NI to perform paint formulation and analytical work. JBA then contracted with Utility Development Corporation (UDC) to perform the paint formulation effort. UDC formulated numerous UV-curable paints and sprayed and cured them on steel and aluminum test panels and fiberglass/epoxy composite specimens from 155mm M48A1 projectiles. Testing on the panels and specimens included curing time, adhesion and corrosion resistance. Corrosion testing of panels was also conducted at the Chemical Coatings Laboratory at Ft. Belvoir, VA and at ARDC. NI purchased an ultraviolet curing light and installed it on their 155mm M48A1 production line. NI sprayed and cured several of JBA's UV-curable paints on 155mm M48A1 projectiles. Adhesion and corrosion resistance testing was performed on these projectiles. Results of these tests showed the UV coating to be inferior in performance to the presently used enamel.

The results of the project will not be implemented since ARDC has been requested to investigate the application of chemical agent resistant coatings (CARC) to artillery ammunition. The UV curable coatings exhibited less corrosion resistance than the enamel. Also longer than expected curing times were required for the UV coatings resulting in higher than expected capital and operating costs for implementation. UV curing gives off ozone which may require controls, and the paint is more expensive than the presently used enamel.

Summary report was prepared by Robert Hellem, AMXIB-PG, Production Engineering Division, US Army Industrial Engineering Activity, Rock Island, IL 61299-7260, Commercial (309) 782-5235, AUTOVON 793-5235

MANUFACTURING METHODS AND TECHNOLOGY
PROJECT SUMMARY REPORT (RCS AMCPD-302)

6 7926 Hot Isostatic Pressing (HIP) of Large Cannon Components

PERFORMING ORGANIZATIONS

MSC/INSTALLATION - AMCCOM WATERVLIET ARSENAL
MSC PROJECT OFFICER - PETER THORNTON
PHONE NUMBER - COMMERCIAL - (518) 266-5737
AUTOVON - 974-5872
CONTRACTORS - FIBER MATERIALS INC., Biddleford, ME.,
BABCOCK + WILCOX, Lynchburg, VA., and
CRUCIBLE INC., Pittsburg, PA.

TECHNOLOGY DEVELOPED: The complex configuration required for cannon step thread type breech blocks has continually been a manufacturing problem at Watervliet Arsenal. Twenty-five percent of the rough forging becomes chips during machining.

This two-phased program at Watervliet Arsenal developed a manufacturing process for producing breech blocks by the hot isostatic pressing of gas atomized alloy steel powder. Prototype 8-inch M201 step-threaded breech blocks made from 4335V powder were successfully produced. The fatigue life of two of these components tested exceeded the required safe life criteria of conventionally forged steel breech blocks.

This program successfully demonstrated the hot isostatic pressing of low steel alloy powder manufacturing process for large cannon components. Implementation of this process will result in five hours or $305 per part in labor savings for 8-inch M204 breech blocks. The process is applicable to other large gun tube components that have similar configurations, extensive machining requirements and high property requirements.

This summary report was prepared by R. Russell, AMXIB-PA, Production Engineering Division, U.S. Army Industrial Base Engineering Activity, Rock Island, IL. 61299-7260, Commercial (309) 782-5126, AUTOVON 793-6260.

MANUFACTURING METHODS AND TECHNOLOGY
PROJECT SUMMARY REPORT (RCS AMCPD-302)

6 8254 Automated Surface Coating of Cannon (Painting)

PERFORMING ORGANIZATIONS:

MSC/INSTALLATION: AMCCOM/Watervliet Arsenal
PROJECT OFFICER: V. H. Montuori
PHONE NO: COMMERCIAL - (518) 266-5507
AUTOVON - 974-5507

TECHNOLOGY DEVELOPED: Applying paint to gun tubes requires an excessive amount of time and manpower. It requires approximately 2 1/2 hours per tube to apply one undercoat and two finish coats by manual brushing. Electronic-controlled, hydraulically powered spraying machines are available which will allow controlled paint spraying. These machines can be equipped with automatic air, airless and electrostatic guns which would reduce painting time and improve the finish on gun tubes. The time needed to paint gun tubes could be reduced by at least 75%.

A complete investigation of surface coating procedures and methods, both within the government and private industry, was conducted. The Watervliet Arsenal Operations personnel worked to arrive at a feasible concept design for automating the application of surface coating on cannon tubes. A working group was formed, discussions and on-site visits with vendors were held, and a variety of paint application methods were reviewed. It was determined that the application of paint to cannon tubes and breech mechanisms will be sprayed rather than brushed. A spray booth and drying booth along with the spray equipment and operator safety gear and clothing comprises an initial paint spray application system. A general cart has been designed and fabricated for transporting cannon tubes and other components into the system. Due to space constraints in Bldg 110 where the system is installed, the complete automation of paint application and material handling will be considered at a later date. Ideally, a building dedicated to paint application should be constructed.

Summary report was prepared by Robert Hellem, AMXIB-PG, Production Engineering Division, US Army Industrial Engineering Activity, Rock Island, IL 61299--7260, Commercial (309)872-5235, AUTOVON 793-5235

6 8267 Stress Peening of Helical Compression Springs

PERFORMING ORGANIZATIONS

MSC/INSTALLATION: AMCCOM/ARDC, Dover, N.J.
PROJECT OFFICER: Dr. John Burlingame
PHONE NO: COMMERCIAL (201) 724-2596
AUTOVON 880-2596
CONTRACTOR: Teledyne Engineering Services
LOCATION: Waltham, MA

TECHNOLOGY DEVELOPED: The failure of weapon springs results in an ineffective weapon and a loss of fire power. An example is the recoil spring for the M140 gun mount which has a high incidence of early breakage. A method to increase the fatigue life and insure the reliability of critical springs is with the use of stress peening techniques. Stress peening is a relatively new field of technology for springs and little effort has been applied to establish the proper and effective production processes for stress peening of springs.

The process of stress peening is similar to conventional shot peening except that the component being peened is subjected to an applied stress during the peening operation. This procedure can result in the creation of higher compressive residual stresses than would be obtained without the stressing. The subsequent superimposed service stresses then result in a lower total stress and, consequently, enhanced fatigue properties.

Springs of three different wire sizes, 0.125, 0.50, and 1.0 inch diameter, were fabricated to be geometrically similar. Although music wire was initially desired, such wire is not available in the larger sizes. Chrome-vanadium spring wire was used for the 1/2 inch size and chrome-silicone wire was used for the 1 inch size.

A high-stress design was necessary in order that fatigue tests could be planned for failure at something less than 100,000 cycles. Allowance had to be made for higher-than-usual stress levels in anticipation of high fatigue strength resulting from the stress-peening process. Thus the springs were designed so that solid compression would give stresses well in excess of the yield strength. This design would then enable the development of high enough cyclic stresses to cause failure without the springs going solid. Springs were conventionally peened or stress-peened using three different stress levels, three different shot sizes and three different shot intensities. Ninety-nine springs of each size in the test program were selected from the total of 121 which represented the least spread in length. The range of length was small enough that the springs could be considered identical with regard to load-deflection-stress characteristics. Optimum test results by optimum stress peening are compared in table 1, using the unpeened condition as a reference.

MANUFACTURING METHODS AND TECHNOLOGY
PROJECT SUMMARY REPORT (RCS AMCPD-302)

SUBJECT: 6-8267 Stress Peening of Helical Compression Springs

TABLE 1

Fatigue strength * improvement by conventional peening and by optimum stress peening.

WIRE SIZE (dia.-in.)	1/8	1/2	1
No peening	173ksi	156ksi	110ksi
Conventional peening	205ksi	190ksi	166ksi
Improvement over unpeened	18%	22%	51%
Stress peening	247ksi	219ksi	174ksi
Improvement over unpeened	43%	40%	58%
Improvement over conventional	21%	15%	5%

* At 100,000 cycle life

The results of the tests showed that:

a. The fatique strength under any of the peening conditions tested was markedly greater than that of non-peened springs.

b. The conventional shot peening treatment resulted in increases in fatigue strength of 18%, 22%,and 51%, respectively, for springs of 0.125, 0.50 and 1.0 inch diameter wire. These increases correspond to increases in fatigue life by factors of 3.8, 4.2 and 10.4, respectively.

c. The stress peening process produced additional increases in fatigue strength of 21%, 15% and 5% over the conventionally peened conditions for the 0.125, 0.50 and 1.0 inch wire sizes, respectively, (based on the conventionally peened condition) by factors of 22.2, 14.0 and 14.6, respectively.

d. A pre-stress level of 50,000 psi during shot peening resulted in increases in fatigue strength at/or near the optimum values.

Conventional peening, as expected, exhibits very favorable cost benefit factors for all spring sizes. In comparing the cost benefit factors for the stress peening versus the conventional peening, it was found that the stress peening process would be economically beneficial for the two larger spring sizes but not for the smaller size. This is due to the higher initial cost of large springs as compared to the small springs. Results of this projects have not yet been implemented but are being considered for large caliber weapon systems.

Summary report was prepared by Robert Bellom, AMSIB-PC, Production Engineering Division, US Army Industrial Base Engineering Activity, Rock Island, IL 61299-7260, Commercial (309) 782-5235, AUTOVON 793-5235

MUNITIONS

MANUFACTURING METHODS AND TECHNOLOGY
PROJECT SUMMARY REPORT (RCS AMCPD-302)

3 3449 Optional Propellant Ingredients

PERFORMING ORGANIZATIONS:

MSC/INSTALLATION: MICOM
PROJECT OFFICER: J. Murfree
PHONE NUMBER: COMMERCIAL - (205 876-8876
AUTOVON - 746-8876
CONTRACTOR: SRI International
LOCATION: Menlo Park, CA 94025

TECHNOLOGY DEVELOPED: Current missile systems such as VIPER, GSRS, Pershing etc., utilize propellant systems utilizing hydroxyterminated polybutadiene (HTPB) binders. The HTPB binders require a curing agent isophorone de-isocynate (IPDI) now being produced in West Germany by a process using the hazardous poison gas, phsogene ($COCl_2$). Restrictive government regulations contained in the Toxic Substance Control Act, Job Safety and Health Act, and low volume production limit the interest of industry in establishing production capabilities in the United States.

The objective of this last phase of a three phase effort was to produce IPDI by an alternate process not involving $COCl_2$. The oxalyl chloride process effectively eliminated the use of $COCl_2$. However, the price of starting materials and low yield due to separation problems limit the oxalyl chloride process commercialization while a foreign source is available.

A process that avoids the use of $COCl_2$ and meets the governments' safety and health standards was developed. However, the high cost of this process means that it will be more economical to continue the purchase of IPDI from foreign sources.

Summary report was prepared by Tom Jameson, AMXIB-PG, Production Engineering Division, U.S. Army Industrial Engineering Activity, Rock Island, IL 61299-7260, Commercial (309) 782-6586, AUTOVON 793-6586

MANUFACTURING METHODS AND TECHNOLOGY
PROJECT SUMMARY REPORT (RCS AMCPD-302)

5 1354 Sludge Volume Reduction and Disposal Process

PERFORMING ORGANIATIONS

MSC/INSTALLATIONS: AMCCOM/Pine Bluff Arsenal (PBA)
PROJECT OFFICER: Ken Mazander
PHONE NO: COMMERCIAL - (501) 541-3536
AUTOVON - 966-3536
CONTRACTOR: Pfeifer Plumbing and Heating Co.
LOCATION: PBA

TECHNOLOGY DEVELOPED: This effort addresses the problem of storing, recovering, dewatering, and disposing of sludge at the Central Wastewater Treatment (CWT) plant at the Pine Bluff Arsenal.

Data from bench studies and operation of the existing Pilot Waste Treatment Plant was implemented by designing/installing a pilot scale on-line sludge dewatering process.

Conclusions from the studies made follow:

° Equalization of CWT influent with preclarification is feasible and would be cost effective. However, automatic control instrumentation appears to be a less costly alternative to the same end.

° Improved chemical treatment can be achieved by reducing final treatment basin pH to 8.0 from the present 10.5. Treatment of heavy metals and phosphates will be acceptable, less sludge will be formed, and lagoon effluent pH adjustment can be eliminated.

° Recovery and handling of lagoon sludge can be achieved by dredging and pumping with low-shear equipment such as progressing cavity pumps.

° In-line settling is rapid and can be effective using gravity settlers. The horizontal belt sludge press utilized in the pilot process dewatered CWT sludge effectively to 37% solids in the sludge cake.

° The concept of sludge volume coefficients did not yield a constant value. However, it did confirm that minimum sludge volume operating parameters exist, and helped to define them.

° The settleable sludge solids present in the treated CWT effluent are largely due to the treatment chemicals added. A significant reduction in generated sludge volume is possible if minimum sludge volume parameter operating ranges are utilized by CWT personnel. Quality of lagoon discharge water will not be diminished.

Summary report was prepared by Wayne R. Hiersemann, AMXIB-PG, Production Engineering division, U.S. Army Industrial Engineering Activity, Rock Island, IL 61299-7260, Commercial (309) 782-5235, AUTOVON 793-5235

MANUFACTURING METHODS AND TECHNOLOGY
PROJECT SUMMARY REPORT (RCS AMCPD-302)

5 1711 Red Phosphorus Pollution Abatement Evaluations

PERFORMING ORGANIZATIONS

MSC/INSTALLATION: AMCCOM/Pine Bluff Arsenal (PBA)
PROJECT OFFICER: D. J. Garcia
PHONE NO: COMMERCIAL - (501) 541-3612
AUTOVON - 966-3612
CONTRACTOR: Garver & Garver/University of Arkansas
LOCATION: Little Rock, AR/Fayetteville, AR

TECHNOLOGY DEVELOPED: During production and testing of pyrotechnic munitions planned for PBA, wastewater, solid waste, hardware and/or fabricated components will become contaminated with phosphorus. These wastes must be treated since they are toxic to the environment. The objective of this project was to provide pollution abatement design criteria for phosphorus operations that will provide an environmentally acceptable discharge.

Red phosphorus (RP) was shown to be an aquatic toxicant in tests conducted at PBA. From this it was concluded that elemental phosphorus wastewater cannot be treated in PBA's existing Central Waste Treatment Facility (CWTF) without pretreatment.

Extensive literature surveys of wastewater treatment unit operations were conducted. Also, RP manufacturers, suppliers and processors were surveyed to learn common industrial waste treatment methods. Enough was learned to develop design criteria for a RP M8E3 Grenade pilot production facility and for the XM819, 81mm, RP smoke pellets Initial Production Facility (IPF).

The studies also identified phosphorus sludge disposal and white phosphorus (WP) wick demilitarization as areas needing further efforts to complete the life cycle of elemental phosphorus munitions.

Summary report was prepared by Wayne R. Hierseman, AMXIB-PG, Production Engineering Division, U.S. Army Industrial Engineering Activity, Rock Island, IL 61299-7260, Commercial (309) 782-5235, Autovon 793-5235.

MANUFACTURING METHODS AND TECHNOLOGY
PROJECT SUMMARY REPORT (RCS AMCPD-302)

5 4061 Nitroguanidine Process Optimization

PERFORMING ORGANIZATIONS

MSC/INSTALLATION: AMCCOM
PROJECT OFFICER: Mr. S. J. Rosenberg
PHONE NO: COMMERCIAL - (201) 724-3007
AUTOVON - 880-3007
CONTRACTOR: Hercules Incorporated
LOCATION: Radford, VA

TECHNOLOGY DEVELOPED: The objective of this project was to develop a program for operating the demonstration plant which would systematically investigate and optimize pollution abatement processes.

A wastewater characterization study was conducted at the Sunflower Army Ammunition Plant (SFAAP) nitroguanidine demonstration plant. Methods of process optimization were developed for wastewater reduction in the main nitroguanidine plant. Process modifications were suggested such as entrainment separators for the guanidine nitrate (GN) evaporators and nitroguanidine (NQ) crystallizers and chillers for the GN and NQ crystallizers and sulfuric acid concentrator. Wastewater treatment methods were also investigated. Pilot plant scale testing, including adsorption of NQ on granular activated carbon and GN removal by ion exchange, resulted in design criteria for a provisional treatment system for the SFAAP main NQ production facility.

The process changes recommended will reduce the wastewater load and thereby reduce the costs associated with treating and purifying the wastewater. The findings will enable the main plant to meet the EPA compliance date of July 1987.

Seven of the 18 recommended process changes have been or are in the process of being implemented. Implementation of the remaining recommendations will proceed according to a Master Plan established by SFAAP. An advanced pilot plant is being constructed at SFAAP by USATHAMA to evaluate selected methods of treating the wastewaters.

Summary report was prepared by A. Kource, Jr, AMXIB-PG, Production Engineering Division, U.S. Army Industrial Base Engineering Activity, Rock Island, IL 61299-7260, Commercial (309) 782-5235, AUTOVON 793-5235

MANUFACTURING METHODS AND TECHNOLOGY
PROJECT SUMMARY REPORT (RCS AMCPD-302)

5 4149 Loading of 30mm ADEN/DEFA Ammunition

PERFORMING ORGAANIZATIONS:

MSC/INSTALLATION: AMCCOM
PROJECT OFFICER: F. Stulb
PHONE NO: COMMERCIAL - (201) 724-4713
AUTOVON - 880-4713
CONTRACTOR: Honeywell
LOCATION: Minnetonka, MN

TECHNOLOGY DEVELOPED: This effort developed the Rod-Extrude-Draw process for manufacturing the XM789 High Explosive Dual Purpose (HEDP) cartridge. The XM789 HEDP is a shaped charge 30mm round intended for use in the US Army's YAH-64 Advanced Attack Helicopter (AAH) and is compatable with the British ADEN and the French DEFA guns.

The operations for high volume production of the XM789 were developed in three phases, as follows: Impact Extrusion of Projectile Bodies, Fabrication of Fluted Shaped-Charge Liners and High Explosive Loading.

Phase 1 - Impact Extrusion of Projectile Bodies - improved on a preliminary process for the extrusion of the HEDP projectile body by incorporating a punch press operation with the National Cold Former, a machine which extrudes 4130 steel. The advantages of the tooling used on the National Cold Former and the press include good material flow, improved interior and exterior finish, excellant dimensional stability and reduced tool breakage.

Phase 2 - Fabrication of Fluted Shaped Charge Liners - utilizing a semi-automatic special machine, developed the machining and fixturing parameters for forming a 30mm copper liner. The copper liner is formed using copper specification CDA-101 into a liner having sixteen flutes. Work completed under Phase 2 established a tentative high volume production process.

Phase 3 - High Explosive Loading - developed the time-temperature-pressure parameters for loading PBXN-5, Type II, Class 3 explosive. PBXN-5 is a hot pressable composition of HMX with 4.5 to 5.5 percent (by weight) of Vitron A as a binder. The parameters developed in Phase 3 resulted in a continuous loading process utilized by the U.S. Army Armament Munitions and Chemical Command.

The project results have been implemented through an Initial Production Facility (IPF) established at the Joliet Army Ammunition Plant (JAAP) under project #5780018. The facility has produced buys for FY82 (150,000 rounds), FY83 (1,450,000 rounds) and FY84 (375,000 rounds). To date, a savings of $4.56/round x 1,984,000 = $9,047,000 has been generated using this process.

Summary report was prepared by Tom Jameson, AMXIB-PG, Production Engineering Division, U.S. Army Industrial Engineering Activity, Rock Island, IL 61299-7260, Commercial (309) 782-5235, AUTOVON 793-6586

MANUFACTURING METHODS AND TECHNOLOGY
PROJECT SUMMARY REPORT (RCS AMCPD-302)

5 4214-01 Pollution Engineering Technology Requirements

PERFORMING ORGANIZATIONS:

MSC/INSTALLATIONS: AMCCOM/Iowa AAP/Radford AAP (RAAP)/Badger AAP
PROJECT OFFICER: J.M. Swotinsky
PHONE NO: COMMERCIAL - (201) 328-4284
AUTOVON - 880-4284
CONTRACTORS: Mason-Hanger/Hercules/Olin
LOCATIONS: Middletown, IA/Radford, VA/Baraboo, WI

TECHNOLOGY DEVELOPED: Work was accomplished in three phases:

I. Program Control, Coordination & Support - Continuous coordination and liaison was maintained with all command activities as well as other Government agencies on programs to control environmental pollution. A "Chemical Assessment Program" was developed for parts-per-billion measurement of various TNT associated nitrobodies and the analysis of treated wastewater from four different treatment methods. Explosive standards have been acquired in order to compile a library of reference gas chromatograph spectra curves. Some of these explosive standards were obtained from the Armament Research and Development Center (ARDC) and some from the U.S. Army Toxic and Hazardous Materials Agency (USATHAMA).

II. Acetone/Ethanol Solvent System for Acceptable Vapor Levels in the Manufacture of SB Propellant - A final technical report has been received from RAAP, reviewed, and prepared for publication The results indicate that an acetone/ethanol solvent system will produce acceptable propellant. However, the water content of the NC for the mix must be below 3.0 wt percent. Solvent vapor levels of acetone and ethanol in the work area were below the OSHA maximum allowables. The acetone and ethanol can be recovered in the existing tower system by rearranging the separation sequence and adding reboilers and additional overhead condenser capacity.

III. Removal of NO_x Fumes by Hydrogen Peroxide Scrubbing - A bench scale evaluation was made of the effect of hydrogen peroxide (H_2O_2) on the scrubbing of nitrogen oxides (NO_x) from air streams with dilute nitric acid. It was found that the additon of H_2O_2 allowed the removal of more than 95% of the NO_x. Optimum nitric acid concentration is about 40%. A 0.5% to 1.0% concentration of H_2O_2 is used to stoichiometrically oxidixe the NO_x to HNO_3. Design criteria were developed for pilot plant testing of H_2O_2 scrubbing for removing NO_x from effluent air streams for NC production and from HNO_3 production by ammonia oxidation.

Summary report was prepared by Wayne R. Hierseman, AMXIB-PG, Production Engineering Division, U.S. Army Industrial Engineering Activity, Rock Island, IL 61299-7260, Commercial (309) 782-5235, AUTOVON 793-5235

MANUFACTURING METHODS AND TECHNOLOGY
PROJECT SUMMARY REPORT (RCS AMCPD-302)

5 4214-02 In-Plant Reuse of Pollution Abated Waters

PERFORMING ORGANIZATIONS

MSC/INSTALLATIONS: AMCCOM/LCWSL/Holston AAP/Radford AAP/Kansas AAP/
Badger AAP/Volunteer AAP
PROJECT OFFICER: J. M. Swotinsky
PHONE NO: COMMERCIAL - (201) 328-4284
AUTOVON - 880-4284
CONTRACTORS: Holston Defense Corp/Hercules/Day & Zimmerman/Olin/ICI Americas
LOCATIONS: Kingport, TN/Radford, VA/Parsons, KS/Baraboo, WI/Chattanooga, TN

TECHNOLOGY DEVELOPED: The main objective was to abate water pollution at Army Ammunition Plants (AAPs) by recycling and reusing water while concurrently recovering waste acids and other contaminants, also for reuse. Pollution must be abated at AAPs in order to comply with EPA and state regulatory agency requirements as well as to obtain discharge permits.

At Holston AAP (HSAAP) the quality and quantity of process, cooling, and make-up water was reviewed. The cost of primary waste water treatment was found to have a greater impact on cost effectiveness of waste water reduction proposals than the cost of tertiary waste water treatment. Also, at HSAAP, it was concluded that the single most cost effective waste water reduction proposal is the replacement of Incorporation/Finishing Area dust scrubbers with new high-efficiency scrubbers.

Studies at Radford AAP showed that implementation of a recycle/reuse system was economically unattractive compared to the economics for treating actual river water. However, if additional discharge restrictions are imposed, then recycle/reuse of water will be more economical than treating river water.

An engineering study conducted at Kansas AAP determined that, if the plant were in a totally active state, several areas of the plant demonstrate technical feasibility and economic attractiveness in support of recycle and reuse of pollution abated waters.

Results at Badger AAP indicate that activated carbon can absorb ethyl acetate from the reverse osmosis permeate as well as from synthetic solutions. Ethyl acetate can be recovered by steam regeneration of the carbon.

An engineering study at Volunteer AAP (VAAP) was conducted on converting the Sulfuric Acid Recovery (SAR) units to double absorption systems, including the design modification required and estimated costs. Based upon this study, it was recommended that the SAR's be modified to the double absorption system when the red water disposal/sulfite recovery plant is applied at VAAP. It was further recommended that ammonia scrubbing of the tail gas at the existing SAR's at VAAP be thoroughly studied as an economically preferable alternative to modification to double absorption.

Summary report prepared by Wayne R. Hierseman, AMXIB-PG, Production Engineering Division, U.S. Army Industrial Engineering Activity, Rock Island,

MANUFACTURING METHODS AND TECHNOLOGY
PROJECT SUMMARY REPORT (RCS AMCPD-302)

5 4214-03 Low Cost System to Abate Nitrobody Pollution

PERFORMING ORGANIZATIONS

MSC/INSTALLATIONS: AMCCOM/Iowa AAP/Kansas AAP/Hazards Research Corp/
New York Polytechnic Institute
PROJECT OFFICER: J.M. Swotinsky
PHONE NO: COMMERCIAL - (201) 328-4284
AUTOVON - 880-4284
CONTRACTORS: Mason-Hanger/Day & Zimmerman/Hazards Research Corp./
New York Polytechnic Institute/
LOCATIONS: Middletown,IA/Parsons, KS/Rockaway, NJ/New York, NY

TECHNOLOGY DEVELOPED: Future standards, as deduced from toxicological studies by the Office of the Surgeon General, will become more stringent, making carbon adsorption systems even more costly than they are now. This study evaluated alternative technologies for the treatment of pink wastewater in order to reduce the cost associated with the current baseline technology. The alternatives studied were UV/Ozonolysis, surfactant technology and white oil solvent extraction. The work provided design data for the most effective/ economical treatment of pink wastewater as well as support for new MCA and MOD programs involving loading and manufacturing operations.

Results of a pilot plant evaluation demonstrated the treatment effectiveness of UV/Ozonolysis by reducing a TNT contamination from 120 mg/l, to less than 0.1 mg/l. The UV/Ozonolysis method, however, was not cost effective ($7.63/ 1000 gallons) compared to carbon adsorption technology ($4.97/1000 gallons) without thermal regeneration. It was observed, though, that changes in certain design details inherent in the system could make UV/Ozonolysis cost competitive.

Another study showed that UV/Ozonolysis is effective in treating wastewaters containing RDX. UV/Ozonolysis reduced RDX from a nominal influent level of 20 mg/l to an effluent level of less than 0.2 mg/l. This technology is too expensive for large volumes of wastewater, i.e., approaching 50,000 gallons/day. Even so, it can be cost effective for smaller volumes of wastewater.

Evaluation of the liquid-liquid countercurrent extraction process using white oil solvent showed it to be very effective in the removal of TNT nitrobodies from pink wastewater. However, the treatment cost of $20.57/1000 gallons makes this process prohibitive as an alternate treatment technology.

Surfactant separation technology has been demonstrated to be both economically feasible and effective in the treatment of TNT and RDX/HMX. This technology degrades completely the nitrobody contaminant molecule.

Summary report was prepared by Wayne R. Hierseman, AMXIB-PG, Production Engineering Division, U.S. Army Industrial Engineering Activity, Rock Island, IL 61299-7260, Commercial (309) 782-5235, AUTOVON 793-5235

MANUFACTURING METHODS AND TECHNOLOGY
PROJECT SUMMARY REPORT (RCS AMCPD-302)

5 4226 On-Line Monitors for Water Pollutants

PERFORMING ORGANIZATIONS

MSC/INSTALLATIONS: AMCCOM/Radford AAP/Holston AAP
PROJECT OFFICER: J.M. Swotinsky
PHONE NO: COMMERCIAL - (201) 328-4284
AUTOVON - 880-4284
CONTRACTORS: Hercules Inc/Holston Defense Corp.
LOCATIONS: Radford, VA/Kingsport, TN

TECHNOLOGY DEVELOPED: Army ammunition plants are discharging a wide variety of pollutants which are unique to military munitions production and are hazardous and/or toxic. Studies by the Office of the Surgeon General (Army) have shown toxic effects even at fractional part-per-million concentrations. The 1977 amendments to the Water Pollution Control (Clean Water) Act mandate the monitoring of specific pollutants to insure their control at concentrations which will not be a threat to the environment. No commercially available monitoring instruments are capable of monitoring these toxicants continuously in the field at the required low levels. However, research and development programs developed candidates for the continuous monitoring of significant pollutants at very low levels. This project was initiated to evaluate those special purpose analyzers.

Four special purpose analyzers were field evaluated on five different wastewater streams at the Radford Army Ammunition Plant (RAAP). The analyzers were the high-performance liquid chromatograph (HPLC) and three voltammetric (polarographic) type analyzers. The latter three were the Monsanto II polarograph, a polarograph developed by the Naval Weapons Center (NWC), China Lake, CA and the CONTOC (conductivity organic nitrates, total organic carbon) monitor. The application of the HPLC for continuous field detection and quantitative determination of low level concentration (less that 0.2 ppm) of trinitrotoluene (TNT), nitroglycerin (NG), dinitroglycerin (DNG), diethylene glycol dinitrate (DEGDN), nitroguanidine (NQ), and the isomers of dinitrotoluene (DNT) in processing effluents was successfully demonstrated. None of the voltammetric instruments proved capable of reliably monitoring these same compounds.

In addition, a preliminary investigation and site preparation was completed at Holston AAP in preparation for studies similar to those conducted at RAAP.

In conclusion, testing thus far on five process wastewater streams has established the HPLC as the best instrument for continuous simultaneous on-line monitoring of TNT, NG, DNG, DEGDN, NQ and DNT.

Summary report was prepared by Wayne R. Hierseman, AMXIB-PG, Production Engineering Division, U.S. Army Industrial Engineering Activity, Rock Island, IL 61299-7260, Commercial (309) 782-5235, AUTOVON 793-5235.

MANUFACTURING METHODS AND TECHNOLOGY
PROJECT SUMMARY REPORT (RCS AMCPD-302)

5 4231 In-Plant Reuse of Pollution Abated Waters

PERFORMING ORGANIZATIONS

MSC/INSTALLATION: AMCCOM/Pine Bluff Arsenal
PROJECT OFFICER: J. M. Swotinsky
PHONE NO: COMMERCIAL - (201) 328-4284
AUTOVON - 880-4284
CONTRACTOR: None
LOCATION: N/A

TECHNOLOGY DEVELOPED: Pine Bluff Arsenal (PBA) has a highly varied pyrotechnic chemical mission. Contaminated wastewater is generated at the two principal smoke production facilities: colored hexachlorethane and red phosphorus. Wastewater from each of these process lines is combined at a central location and treated at the Central Waste Treatment Facility (CWTF). The latter plant is a heavy consumer of two valuable resources: water and chemicals. Presently, the combined wastewater is treated with carbon, alum, lime/sulfuric acid (pH adjustment), and polymer, and discharged to a lagoon which overflows into the Arkansas River.

Work at PBA was conducted to investigate various treatment technologies to minimize both treatment chemical utilization and water consumption. The main objective was to abate water pollution by recycling and reusing water while concurrently recovering waste acids and other contaminants also for reuse. The ultimate objective is compliance with the Environmental Protection Agency (EPA) guidelines for zero discharge of pollutants.

A pilot carbon column treatment plant was installed to evaluate the treatment of the combined PBA wastewater effluent. Results, thus far, indicate that granular carbon column treatment is necessary to meet both current and future EPA chemical and biological discharge criteria.

Since PBA does not operate all of their processes on an annual basis or at the same time or mode, it will take several years to effectively evaluate this system to meet effluent quality guidelines. During this time, projected savings which can be realized as a result of improved treatment, reduction of total organic carbon(TOC), better control of aquatic toxicants, and/or reduction of sludge for ultimate disposal will all be documented.

Summary report was prepared by Wayne R. Hierseman, AMXIB-PG, Production Engineering Division, U.S. Army Industrial Engineering Activity, Rock Island, IL 61299-7260, Commercial (309) 782-5235, AUTOVON 793-5235

MANUFACTURING METHODS AND TECHNOLOGY
PROJECT SUMMARY REPORT (RCS AMCPD-302)

5 4533 In-Process Hazards Evaluation and Classification of LOVA Propellant

PERFORMING ORGANIZATIONS:

MSC/INSTALLATION: ARDC
PROJECT OFFICER: A. Graff
PHONE NO: COMMERCIAL - (201) 724-3637
AUTOVON - 880-3637
CONTRACTOR: Naval Ordinance Station (NOS)
LOCATION: Indian Head, MD

TECHNOLOGY DEVELOPED: The readiness, survivability and effectiveness of high explosive munitions on naval ships, tanks, self-propelled artillary, aircraft and production/storage facilities have always concerned the Department of Defense (DOD). Until recently, triple base propellants were the only available material to fill thi need.

Triple base propellants are now being superseded by a new class of insensitive, low vulnerability ammunition (LOVA) based upon nitramine. The nitramine selected being called by various names mainly Cyclonite, Hexogen, T4 and RDX. This material was first prepared by Henning in 1899 and later by Von Hertz in 1922 who recognized its value as an explosive. The explosive was not used on a large scale in ammunition until World War II.

The Hazards Evaluation was initiated in 1983 by the Large Caliber Weapons System Laboratory under the US Army's Manufacturing Methods and Technology Program. The primary objective of this program was to develop on a timely basis, manufacturing processes, techniques, and equipment for production.

Utilizing procedures developed by the Illinois Institute of Technology Research Institute (IITRI) the in-process hazards of a batch manufacture of LOVA propellant were evaluated. Classification testing was divided into sensitivity appraisal and effects evaluation. The NATO/UN classification criteria were used resulting in a hazards classification of 1.1A for the LOVA dough through the mixing cycles and 1.3A for the remaining process operations. Test results indicate a need for re-evaluating of the criteria used to judge the hazard class for LOVA type propellants with stronger emphasis on their relative insensitivity to initiation.

Based on the results of this investigation a batch process would produce material for $9.25 per pound while a continous process would cost $8.79 per pound plus requiring less floor space and reducing capital costs. The continuous process would also permit less hazardous quantities in residence, reduce personnel exposure and increase production uniformity.

Summary report was prepared by Tom Jameson, AMXIB-PG, Production Engineering Division, US Army Industrial Engineering Activity, Rock Island, IL 61299-7260, Commercial (309) 782-6586, AUTOVON 793-6586

NON-METALS

MANUFACTURING METHODS AND TECHNOLOGY
PROJECT SUMMARY REPORT (RCS AMCPD-302)

E 3709 Continuous Length Fuel Hose

PERFORMING ORGANIZATIONS:

MSC/INSTALLATION: TROSCOM/BRDC
PROJECT OFFICER: Amanda McKenna
PHONE NO: COMMERCIAL - (203) 664-5972
AUTOVON - 354-5972
CONTRACTOR: Durodyne, Inc.
LOCATION: Tucson, AZ

TECHNOLOGY DEVELOPED: The production of large diameter hose in continuous lengths has been a dream of rubber engineers for more than a half century. Production of large diameter hose has been limited to the length of the mandrel on which it was made, usually about fifty feet. Splicing or vulcanizing together short lengths results in increased weight, bulkiness and possible weak spots in the line. Additionally, fuel hose usually requires a bias-ply fabric wrap which tends to twist and kink at the joints.

There is a need for light-weight, continuous-length hose for rapid installation to supply fuel in forward areas. Specifications generally describe 4-inch hose to be supplied in lengths of 500 feet between couplings. This hose is packed in flaking boxes and dispensed from the rear of a moving truck.

An investigation to fabricate a single length, unspliced 500 foot fuel hose was conducted in three phases:

PHASE I consisted of the selection of one out of four proposed methods, to be chosen on the basis of production ease, end product reliability, anticipated Government savings and other factors. The four methods proposed were a) inflatable mandrel; b) advancing mandrel; c) loomed jacket; and d) braided jacket hose. The advancing mandrel method was selected as the most promising.

PHASE II consisted of the verification of the advancing mandrel technique for the fabrication of long length hose. This method, combined with an ethylene glycol cure system, advanced the state-of-the-art in long length, large diameter hose. Phase II established that this production method was feasible.

PHASE III tasks were to fabricate, cure, and test two 500 foot lengths of 4" hose. They were prepared, but due to their length and fragility, both were destroyed in the curing process. Since resolving the cure problems entailed major equipment expenditures, it was decided to terminate the development program. Another reason for not continuing with the effort was that overseas private firms entered the market with a manufacturing process that appeared to duplicate this effort.

In summary, new techniques to fabricate 500 ft lengths of uncured hose were successfully developed. Some additional work in the area of curing remains to be carried out.

Summary report was prepared by Wayne R. Hieseman, AMXIB-PG, Production Engineering Division, U.S. Army Industrial Engineering Activity, Rock Island, IL 61299-7260, Commercial (309) 782-5235, AUTOVON 793-5235.

MANUFACTURING METHODS AND TECHNOLOGY
PROJECT SUMMARY REPORT (RCS AMCPD-302)

7 3717 High Temperature Nozzle for 10KW Power Unit

PERFORMING ORGANIZATIONS

MSC/INSTALLATION - TROSCOM/Belvoir Research & Development Center
MSC PROJECT OFFICER - JAMES ARNOLD
PHONE NUMBER - COMMERCIAL - (703) 664-5459
AUTOVON - 354-5459
CONTRACTOR - SOLAR TURBINES INCORPORATED
LOCATION - SAN DIEGO, CA

TECHNOLOGY DEVELOPED: Advances in materials technology have recently produced a new generation of refractory ceramics with property improvements that are significant to gas turbine engine technology. These ceramic materials have higher strength and excellent thermal shock resistance. New simplified production techniques for uniformity of quality are required to make costs competitive or improved over that of the super alloys now used for hot components of gas turbine engines. One application of this technology is the ceramic turbine nozzle assembly designed for operation at 1950°F and above. At these temperatures metals and conventional ceramics or ceramic glasses cannot provide adequate life for military gas turbine engines.

The life and performance of small gas turbine engines is limited by wear in the turbine inlet nozzle when operating in a dusty environment. This project addressed the problems of manufacturing vane nozzles for turbine engines with hot pressed silicon nitride ceramics at a cost near conventional superalloy metal nozzles.

The project accomplished a cost reduction of the ceramic vane nozzle assembly for the Turbomach-Gemini turbine engine to a level where total life-cycle cost of an engine is expected to be improved over a standard superalloy nozzle engine. Over 2300 hours of successful engine endurance testing was performed for the hot pressed silicon nitride vane nozzles. The reliability of the ceramic vane nozzles was excellent. Erosion resistance of the ceramic material was shown to be twice as great as superalloy vanes.

The use of ceramic turbine engine vane nozzles for small auxiliary power units was demonstrated. The technology is applicable to commercial and military engines.

This summary report was prepared by K. Russell, AMXIB-PA, Production Engineering Division, U.S. Army Industrial Base Engineering Activity, Rock Island, IL. 61299-7260, Commercial (309) 782-6226, AUTOVON 793-6226.

APPENDIX I

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HQ, AMC
U.S Army Materiel Command
5001 Eisenhower Avenue — C: (202) 274-6748
Alexandria, VA 22333-0001 — AV: 284-6748

AMCCOM
U.S. Army Armament, Munitions & Chemical Command
ATTN: AMSMC-PBS-A (R) (Mr. Carrol Schumacher) — C: (309) 782-3517/3665
Rock Island, IL 61299-6000 — AV: 793-3517/3665

U.S. Army Armament, Munitions & Chemical Command
Armament Research, Development, and Engineering Center
ATTN: SMCAR-PMP-P (Ms. Loretta Settles) — C: (201) 724-7957
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Building E5101 — C: (301) 724-3418/3586
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Red River Army Depot — C: (214) 838-2001
Texarkana, TX 75501 — AV: 829-2001

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U.S. Army Management Engineering Training Activity
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Rock Island, IL 61299 — AV: 793-4041

AMRDL
U.S. Army Applied Technology Laboratory
Army Research Technology Lab (AVSCOM)
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ATTN: AMSEL-POD-P-G (Mr. Al Feddeler) AV: 995-4926
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Watertown, Sma 02172-0001 AV: 955-5521

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Rock Island Arsenal
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Rock Island, IL 61299-5000 AV: 793-4142

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American Defense Preparedness Association (2 cys)
ATTN: Mr. William Holt, 1700 N. Moore Street, Arlington, VA 22209
American Society for Metals (1 cy)
ATTN: Mr. James Hontas, Metals Park, OH 44073
American Society for Testing and Materials (2 cys)
ATTN: Mr. Samuel F. Etris, Special Assistant, 1916 Race Street, Philadelphia, PA 19103
Assoc. for Intergrated Mfg Tech (2 cys)
ATTN: Ms. Marti DeGraaf, 111 East Wacker Dr., Suite 600, Chicago, IL 60601
Cast Metal Federation (2 cys)
ATTN: Mr. William E. Gephardt, Chairman, Govt. Supply Committee, 4870 Packard Road, Niagara Falls, NY 14304
Center for Utilization of Federal Technology (1 cy)
ATTN: Mr. Edward J. Lehmann, Room 11R, NTIS, Springfield, VA 22161
Electronic Industrial Association (20 cys)
ATTN: Mr. Jean Caffiaux, 2001 I St., N.W., Washington, DC 20006
Forging Industry Association (10 cys)
ATTN: Mr. C. G. Scofield, Room 1121, 55 Public Square, Cleveland, OH 44113
Manufacturing Technology Information Analysis Center, (MTIAC),
ATTN: Mr. Tom Turner, 10 West 35th Street, Chicago, IL 60616

Miscellaneous Organizations (con't)

Metcut Research Associates, Inc. (1 cys)
ATTN: Dr. John Kahles, 3980 Rosslyn Drive, Cincinnati, OH 45209-1196
Society of Manufacturing Engineers (1 cy)
ATTN: Messrs. Thomas Heath, Thomas Akas, One SME Drive, P.O. Box 930, Dearborn, MI 48128

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